

STINFO COPY

UNITED STATES AIR FORCE
RESEARCH LABORATORY



Over-water Noise Propagation Study:
Preliminary Assessment

Micah Downing
Robert A. Lee

September 1998

Final Report for the Period October 1996 to September 1998

20040422 038

Approved for public release; distribution is unlimited.

Human Effectiveness Directorate
Crew System Interface Division
2610 Seventh Street
Wright-Patterson AFB OH 45433-7901

NOTICES

When US Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Please do not request copies of this report from the Air Force Research Laboratory. Additional copies may be purchased from:

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Federal Government agencies and their contractors registered with the Defense Technical Information Center should direct requests for copies of this report to:

Defense Technical Information Center
8725 John J. Kingman Road, Suite 0944
Ft. Belvoir, Virginia 22060-6218

TECHNICAL REVIEW AND APPROVAL

AFRL-HE-WP-TR-2003-0098

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

//Signed//

MARIS M. VIKMANIS
Chief, Warfighter Interface Division
Air Force Research Laboratory

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE September 1998		3. REPORT TYPE AND DATES COVERED Final Report - October 1996 to September 1998
4. TITLE AND SUBTITLE Over-water Noise Propagation Study: Preliminary Assessment			5. FUNDING NUMBERS PE - 62202F PR - 7184 TA - 718416 WU - 71841603	
6. AUTHOR(S) Micah Downing Robert A. Lee				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Research Laboratory, Human Effectiveness Directorate Crew System Interface Division Aural Displays and Bioacoustics Branch Air Force Materiel Command Wright-Patterson AFB OH 45433-7901			8. PERFORMING ORGANIZATION REPORT NUMBER AFRL-HE-WP-TR-2003-0098	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The current propagation algorithms in the Department of Defense NOISEMAP assume soft grassy ground cover for noise propagation. The new noise propagation algorithm to be implemented into NOISEMAP (Version 7.0) accounts for the effects of topography. The algorithm accounts for the reduced attenuation for noise propagation over a water surface by treating it as an acoustically hard surface. This effectively increases the noise exposures that propagate across water surfaces to increase by 3dB. To investigate this modeled effect a noise monitoring study was conducted at Naval Air Station (NAS) Jacksonville and NAS North Island. The primary objective of the study was to evaluate this effect on long-term noise exposures and determine the validity of representing water as an acoustically hard surface in the NOISEMAP algorithms. A secondary objective was to observe the magnitude of variations associated with noise propagation over water. From these preliminary noise studies, some effect of over-water propagation was observed. The comparison supports the use of modeling water surfaces as acoustically hard as a good first approximation. This modeling approach should be incorporated into NOISEMAP. The noise data qualitatively displayed the trend that water surface can enhance noise exposure around an airfield by reducing the ground absorption; however, the data collected were not sufficient to support any quantitative assessment about the exact magnitude of the effect.				
14. SUBJECT TERMS acoustics, over water propagation, aircraft noise, sound propagation			15. NUMBER OF PAGES 28	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

This page intentionally left blank.

PREFACE

This project was conducted by the Air Force Research Laboratory's Human Effectiveness Directorate. This project manager was Dr. Micah Downing and the work was completed under Workunit 71841603 "Environmental Noise Research". The author would like to acknowledge the technical assistance of Dr Ken Plotkin, Wyle Labs, for his contribution to the radar track analysis program that allowed the detailed SEL analysis in this report. The author would also like to acknowledge the sponsorship of Mr Alan Zusman, NAVFACENGCOM, for his sponsorship of this research effort, and assistance is gaining access to the Naval Air Stations (NAS) at Miramar and North Island.

This page intentionally left blank.

TABLE OF CONTENTS

INTRODUCTION.....	1
BACKGROUND.....	2
APPROACH.....	2
DATA COLLECTION.....	5
RESULTS.....	6
NAS JACKSONVILLE.....	6
NORTH ISLAND.....	15
CONCLUSION.....	21
REFERENCES.....	22

LIST OF FIGURES

Figure 1. NAS Jacksonville Noise Monitoring Sites.....	4
Figure 2. NAS Miramar Noise Monitoring Sites	4
Figure 3. NAS Jacksonville Group 1: P-3C Runway 9 Departures Differences between Measured and Calculated SEL's.....	9
Figure 4. NAS Jacksonville Group 1: P-3C Runway 9 Departures Differences between Measured and Calculated SEL's.....	11
Figure 5. NAS Jacksonville Group 3: Miscellaneous Runway 27 Arrivals Differences between Measured and Calculated SEL's.....	12
Figure 6. NAS Jacksonville Time of Day Grouping Average Differences between Measured and Calculated SEL's.....	15
Figure 7. NAS Jacksonville Time of Day Grouping Stand Deviation of the Differences between Measured and Calculated SEL's.....	15
Figure 8. NAS North Island Overwater Noise Study Difference between Measured and Predicted SELs: Runway 18 Departure.....	17
Figure 9. NAS North Island Overwater Noise Study Difference between Measured and Predicted SELs: Runway 29 Arrival	18
Figure 10. NAS North Island Overwater Noise Study Difference between Measured and Predicted SELs: Runway 29 Departure.....	19
Figure 11. North Island NAS Noise Monitoring Average Difference between Measured and Predicted SEL's Grouped by Time of Day.....	21
Figure 12. North Island NAS Noise Monitoring Data St. Dev. of the Differences between Measured and Predicted SEL's Grouped by Time of Day.....	21

LIST OF TABLES

Table 1. Comparison of Measured and Calculated DNL Values at NAS Jacksonville	7
Table 2. Jacksonville Group 1: P-3C Departures from Runway 9;	8
Table 3. Jacksonville Group 2: P-3C Arrivals to Runway 27;	10
Table 4. Jacksonville Group 3: Other Aircraft Arrivals to Runway 27;.....	11
Table 5. NAS Jacksonville Noise Data Grouped by Time of Day	13
Table 6. North Island Group 1: Departure from Runway 18;	15
Table 7. North Island Group 2: Arrivals to Runway 29;	16
Table 8. North Island Group 3: Departures from Runway 29;.....	17
Table 9. North Island Group 4: Arrivals to Runway 36;	18
Table 10. NAS North Island Noise Data Grouped by Time of Day.....	19

OVER-WATER NOISE PROPAGATION STUDY: PRELIMINARY ASSESSMENT

INTRODUCTION

The new noise propagation algorithm to be implemented into NOISEMAP accounts for the effects of topography. This new algorithm was developed by the NATO/CCMS Working Group on Topography Effects on Aircraft Noise¹. The algorithm accounts for the reduced attenuation for noise propagation over a water surface. Calm water is an acoustically hard surface that does not absorb acoustical energy. The current algorithm² employed by NOISEMAP 6.4³ assumes a grassy ground cover for calculation of the attenuation due to ground absorption. To investigate the effect of propagation over water, a noise monitoring study was conducted at Naval Air Station (NAS) Jacksonville and NAS North Island. The primary objectives of the study were to evaluate the effect of noise propagation over water on long-term noise exposure, and to determine the validity of representing the surface of the water as an acoustically hard surface in the NOISEMAP algorithms. A secondary objective was to observe the magnitude of variations associated with noise propagation over water. This study involved collecting noise data with sound level monitors, correlating these data with flight operations, and comparing the measured levels with calculated levels based on the current NOISEMAP 6.4 algorithm. The results from this comparison study are mixed and demonstrate that the propagation of aircraft noise over water involves some complex processes. These two studies are being supplemented by a similar study conducted by the Swedish Armed Forces at Airbase F4 at Ostersund, Sweden. The data from the Swedish study are not included in this report.

BACKGROUND

The primary noise sources around an airfield are the aircraft as they depart and arrive. Aircraft noise occurs both at ground level and at elevated levels. In general, as the noise propagates its level is attenuated by the following: geometric spreading, atmospheric absorption, ground absorption, and barrier interference. When a noise source is at or close to the ground, the ground cover greatly influences the noise levels via ground absorption. (This

of course assumes that the receiver of the noise is on the ground.) However, as the aircraft gains altitude, the effect of the ground cover diminishes as the slant angle increases. Once a slant angle of 45° is reached, the ground has negligible influence on the noise levels.²

Soft porous ground cover, such as tall grass, absorbs significant amounts of the acoustical energy, whereas a calm water surface, that is non-porous, absorbs no acoustical energy. The noise levels at a receiver will be higher when the noise propagates over water versus soft grassy ground cover, given that all other factors are equal. This difference occurs because less energy is attenuated for the noise propagation over water case rather than because the water surface amplifies the noise.

Another influence that groundcover has on noise propagation is through the atmosphere. A large body of water acts as a heat sink and radiates very little heat back into the atmosphere. Land acts as a heat source by absorbing the solar heat and radiating it back into the atmosphere. Thus, the variation of temperature and wind with altitude will differ between land and water, and will influence noise propagation through air. Depending on the atmospheric profile, the noise can be refracted upward or downward. Variations in the atmospheric profile are very complicated at the interface of water and land; hence, this added complexity in noise propagation has the potential to create large variations in the received sound levels on the opposite shore.

Another complicating factor for aircraft noise modeling is the fact that the noise source is always in motion, making it difficult to describe the precise geometry of the location of the noise source in relation to the receiver. Uncertainty in the source location can create errors in the calculated noise levels. All of these factors can create variations in the measured noise levels as well.

APPROACH

For a first look at evaluating the influence of water surfaces on noise propagation, noise monitors were used to sample the noise levels around two separate airfields. Noise data were correlated with air traffic operations to compare measured and calculated Sound Exposure Levels (SEL) for individual events. The results of this comparison study were used to assess the influence of ground cover on noise levels and evaluate the factors associated with variations in the noise levels. It was expected that if water surface had a

strong effect on the noise levels, the measured SELs would be greater than the calculated levels by at least 3 dB. For monitoring sites where there was no significant propagation over water, the measured and calculated values should be in close agreement. The magnitude of variations in the data can be used to assess whether the water surface has a strong effect on the received noise levels.

Noise data were collected with sound level monitors placed in and around two airfields. The selected air bases were NAS Jacksonville, FL and NAS North Island, CA. The monitors were set to record hourly noise levels as well as SEL from individual noise events. Radar tracking data were collected for a portion of the monitoring period and ground weather observations were also collected. The next step was to correlate the noise data with known aircraft operations. The tracking data along with estimated power settings were used to calculate the expected SEL values using the current NOISEMAP 6.4 algorithms. The measured and calculated values were then compared for any trends. If the comparison demonstrated a strong trend for ground cover, then the new modeling approach should improve the accuracy of long-term noise exposure calculations. If no strong trend was demonstrated, the data should be examined to determine other potential influencing factors.

At NAS Jacksonville, nine monitors were placed around the airfield and along the St. Johns River. The St. Johns River is approximately 1.5 to 2 miles wide near the airfield and the water surface was smooth most of the time. The layout of the monitoring sites is shown in Figure 1. The monitoring period was from November 1996 to March 1997 with radar tracking data from 27 January to 14 February 1997. The primary aircraft at NAS Jacksonville during the measurement period was the P-3C, which is a four engine, turboprop aircraft. Operations from the Runway 9/27 cross directly over the river. Land effects dominate the atmosphere since the water surface area is small compared to the land area.

At NAS North Island, ten monitors were placed around the airfield, along Point Loma, and along Coronado Beach. In the bay, the water surface had small waves (<0.5 feet), and at the ocean side, there were the typical surface waves (>3 feet). Figure 2 shows a map of the area along with the monitoring sites. The period of monitoring was from May to September 1997 with radar tracking data from 10 July to 29 August 1997. The primary aircraft at NAS North Island was the S-3, which is a twin-engine turbofan aircraft. NAS

[illegible][illegible]

4

DATA COLLECTION

The noise data were collected with Larson-Davis 820 Sound Level Monitors (LD820). The LD820s were set with the following collection parameters: 24-hour operation, A-weighted, slow, Record hourly Leq, and exceedance SEL (60 dB threshold, 6 second duration, and 3 dB hysteresis). These settings made the minimal SEL value approximately 66 dB. The data monitors were downloaded about every 10 to 15 days. The microphones were set at a height of 1.2 m and away from any buildings at most sites.

The radar tracking data were different at each site. At NAS Jacksonville, the tracking data were retrieved from the FAA radar at Jacksonville International Airport, which is approximately 18 miles north of the airfield. This separation distance resulted in the data being limited to flight altitudes greater than 900 ft MSL. The accuracy of the tracking data is reasonable, although there is no direct way to measure its precision. For the comparison analysis, the flight tracks were estimated below 1000 ft MSL using straight flight segments back to the runway. Estimated power settings from published flight profiles⁴ were used for the calculation.

At NAS North Island, the tracking data were retrieved from an on-site radar that is networked into the Federal Aviation Administration Southern California airspace management network of radars. The data from this site did have some limitations. Limitations of the radar data, due to siting and reflections off buildings in downtown San Diego, resulted in difficulty determining precise aircraft altitudes below 1000 ft. MSL. The tracking data were estimated by use of straight-line segments back to the runway. Estimated power settings were used from published flight profiles.⁵

Both the NAS Jacksonville and the NAS North Island tracking data sets had the limitation that radar tracks could only be associated with an aircraft when flight plans were filed. This resulted in only 20% of the total flight operations being used in the comparison analysis.

Once the exceedance noise data and the tracking data were obtained, the comparison could be completed. From the radar tracking, an estimated time overhead was used to correlate the exceedance noise levels with a particular flight. Then, the SEL was calculated based on the closest point of approach from the radar tracking data. From this point the slant

distance and angle were calculated from each monitoring site so that the SEL could be calculated using the propagation algorithms used by NOISEMAP 6.4. Differences between the measured and expected SEL values were then determined.

Surface weather data were collected at each airfield. For NAS Jacksonville, daily tower logs and surface data were recorded near the runway. For NAS North Island, surface weather data were collected along with limited tower logs. Changes in the temperature and relative humidity were not included since this effect resulted in differences in the expected SELs of less than 1.5 dB.

The last data set involves the traffic counts at each airfield. For NAS Jacksonville, total daily operation counts were recorded. These data allow the comparison of measured and calculated Day-Night Average Sound Level (DNL) values. The measured DNL values were compared to the published DNL values⁴ after being adjusted to the published average busy day operation count. Unfortunately, the traffic counts were not collected at NAS North Island to allow a DNL comparison.

RESULTS

NAS Jacksonville

The data comparison at NAS Jacksonville includes both DNL and SEL comparisons. First, the DNL comparison for the entire monitoring period is presented in Table 1.

Table 1. Comparison of Measured and Calculated DNL Values at NAS Jacksonville
from a Monitoring Period from November 1996 to March 1997

Site	Measured DNL dB	Calculated DNL dB	Difference dB	Comments
1	64.8	54.9	9.9	Ground operations affect noise levels
2	76.1	63.7	12.4	Test stand ops not included in DNL calculation
3	71.1	74.6	-3.5	Site off of runway
4	71.7	64.8	6.9	Ground-to-ground propagation. Mostly pavement.
5	59.8	49.4	10.4	Small bay between site and runway. Ground-to-ground propagation
6	60.2	53.2	7.0	Across river, south of main flight operations.
10	63.8	60.1	3.7	Directly across from runway. Direct flyover, air-to-ground propagation.
11	59.6	55.9	3.7	Across from runway. Slight offset from main flight path.
13	60.1	53.1	7.0	Across river, north of main flight operations.

The sites at which water surface was a potentially significant factor were 5, 6 and 13. From Table 1, these sites had significant differences in the measured and calculated DNL values. At Site 1, the 9.9 dB difference is explained by ground operations that were not accounted for in the calculated DNL. This explanation becomes clear once the individual noise events are discussed later in this section. At Site 2 the 12.4 dB difference occurs because of the operations at the engine test stands that were between the runway and the site. These test stand operations affected only this site. At Site 3, the difference does show good agreement with only a difference of -3.5 dB. This site was just off Runway 27 and the difference results from differences between the actual flight profiles and the estimated profiles. These differences are magnified at this location since it is so close to the runway.

At Site 4, the closet point of approach for any operation occurred while the aircraft was on the runway so the aircraft noise propagation was ground-to-ground propagation. Moreover, the surface between the runway and this site was primarily pavement that is also acoustically hard. Site 5 was along the same line of Site 4 but across a small inlet and about twice as far from the runway. At this site, the measured levels were more than 10 dB greater than the calculated level. The effect of the water surface was seen at the sites across the river. At Sites 10 and 11, only small differences were observed, as expected. At these sites the flight tracks were nearly overhead, and the major noise propagation path was air-to-ground. For Sites 6 and 13, which were two miles from the flight tracks, differences of 7.0 dB were measured in the DNL values. The primary noise propagation was at low slant angles, indicating that the surface would have a major effect on the noise levels.

The comparison of SEL's from individual flights from NAS Jacksonville reinforced the propagation effect of the water surface. The data were separated into three groups: P-3C departures from Runway 9, P-3C arrivals to Runway 27, and other aircraft arrivals to Runway 27. This comparison was limited to events with duration less than 45 seconds to avoid cases where more than one aircraft contributed to an individual noise event. Tables 2, 3 and 4 show the average and standard deviation of the SEL differences between the measured and calculated levels along with the number of comparison points and the percentage of potential events captured.

Table 2. Jacksonville Group 1: P-3C Departures from Runway 9;
SEL Differences for Noise Events with Duration Less Than 45 Seconds;
Difference is Equal to the Measured Minus the Calculated Value

Site	SEL difference, dB	Average	Standard deviation, dB	Data count	% Captured
1	0.8		3.0	29	38
2	-10.6		3.0	52	68
3	-1.4		2.6	54	71
4					0
5	8.8		4.2	22	29
6	3.3		4.9	14	18
10	-4.4		2.7	74	97
13	6.2		4.0	11	14

(Note: Insufficient data was collected at Site 4.)

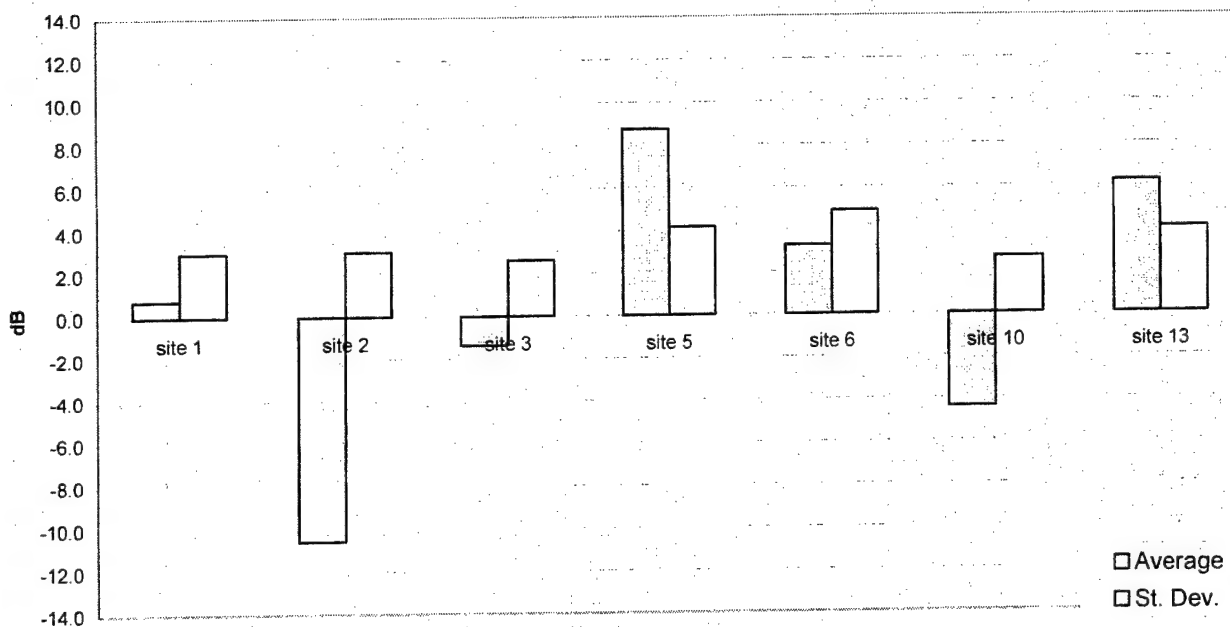


Figure 3: NAS Jacksonville Group 1: P-3C Runway 9 Departures
Differences between Measured and Calculated SEL's

Table 2 and Figure 3 show the differences for the P-3C straight-out departures from Runway 9. The closest point of approach (CPA) to Sites 1, 4 and 5 for this operation were during the takeoff roll. For Sites 2 and 3, the CPA was near the aircraft rotation point. Thus, the noise propagation to Sites 1, 2, 4 and 5 was ground-to-ground. At Site 3, the noise propagation was transitional since the propagation angle was greater than 10° but less than 45° depending on the actual rotation point of the aircraft. For Sites 6 and 13, the flight track was about two miles away, and aircraft were at an altitude of approximately 600 ft. Above Ground Level (AGL) at the CPA. Here too, the noise propagation was characterized as ground-to-ground since the slant angle was approximately 3° . For Site 10, the CPA was directly overhead with the aircraft altitude varying between 800 and 1300 ft AGL. Thus, the noise propagation was air-to-ground for this site.

At Site 1, the SEL comparison shows good agreement with a difference of only 0.8 dB. At Site 2, a large difference of -10.6 dB was observed. The measured levels were much lower than the calculated levels. This difference is likely attributable to the type of ground cover between the runway and this site. Bushes that were approximately ten feet high and

wide covered the ground, increasing the attenuation of the noise. At Site 3, the measured and calculated levels show good agreement with a difference of only -1.4 dB. At Site 5, a large difference of 8.8 dB was observed. This difference was due to the hard surface (pavement and water) between this site and the runway. At Site 6, a difference of only 3.3 dB was measured. This difference was smaller than the 4.9 dB standard deviation, indicating that no strong effect was present. At Site 10, a -4.4 dB difference was measured. This difference is most likely attributable to engine power setting differences. The pilots reduce engine power when they reach an altitude of approximately 1000 ft. AGL. At Site 13, a 6.2 dB difference was measured with a smaller 4.0 dB standard deviation. This difference showed a potentially significant difference, but this site had few observations for comparison.

It should be noted that not all of the flight operations generated measured noise events. This leads to some questions concerning the exact magnitude of the effect of water surface. For long-term noise exposures, louder events impact the noise exposure more than quieter events. Thus, even though the comparison is skewed somewhat to the louder events, the qualitative conclusions drawn from the results are still valid. Site 10 provided the best data for the number of comparison data points. At Site 3, the noise events were sometimes extended into long events because of multiple operations at the airfield.

Table 3. Jacksonville Group 2: P-3C Arrivals to Runway 27;
SEL Differences for Noise Events with Duration Less Than 45 Seconds;
Difference is Equal to the Measured Minus the Calculated Value

Site	SEL difference, dB	Standard deviation, dB	Data count	% Captured
1	9.0	3.9	8	8
2	-0.6	3.8	27	26
3	-1.3	2.9	52	50
4	5.4	3.8	37	36
5	12.8	7.0	54	52
6	11.7	7.0	35	34
10	-4.0	3.1	101	97
13				0

(Note: Insufficient data was collected at Site 13.)

Table 4. Jacksonville Group 3: Other Aircraft Arrivals to Runway 27;
SEL Differences for Noise Events with Duration Less Than 45 Seconds;
Difference is Equal to the Measured Minus the Calculated Value

Site	SEL difference, dB	Standard deviation, dB	Data count	% Captured
1	9.4	7.4	34	65
2	-3.3	6.8	23	44
3	-2.7	7.1	17	33
4	7.4	9.4	16	31
5	11.0	9.8	29	56
6	12.1	10.6	24	46
10	-0.9	6.7	40	77
13	-1.4	3.8	8	15

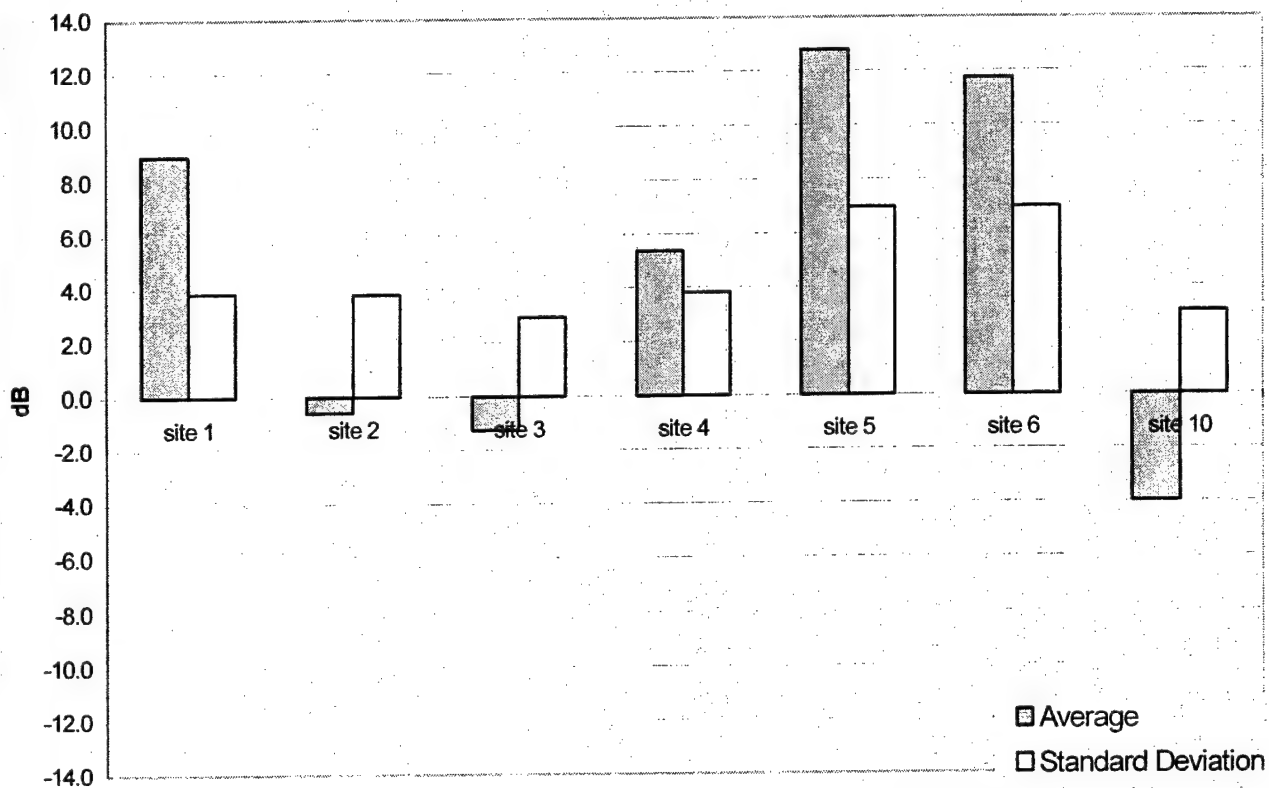


Figure 4: NAS Jacksonville Group 2: P-3C Runway 27 Arrivals
Differences between Measured and Calculated SEL's

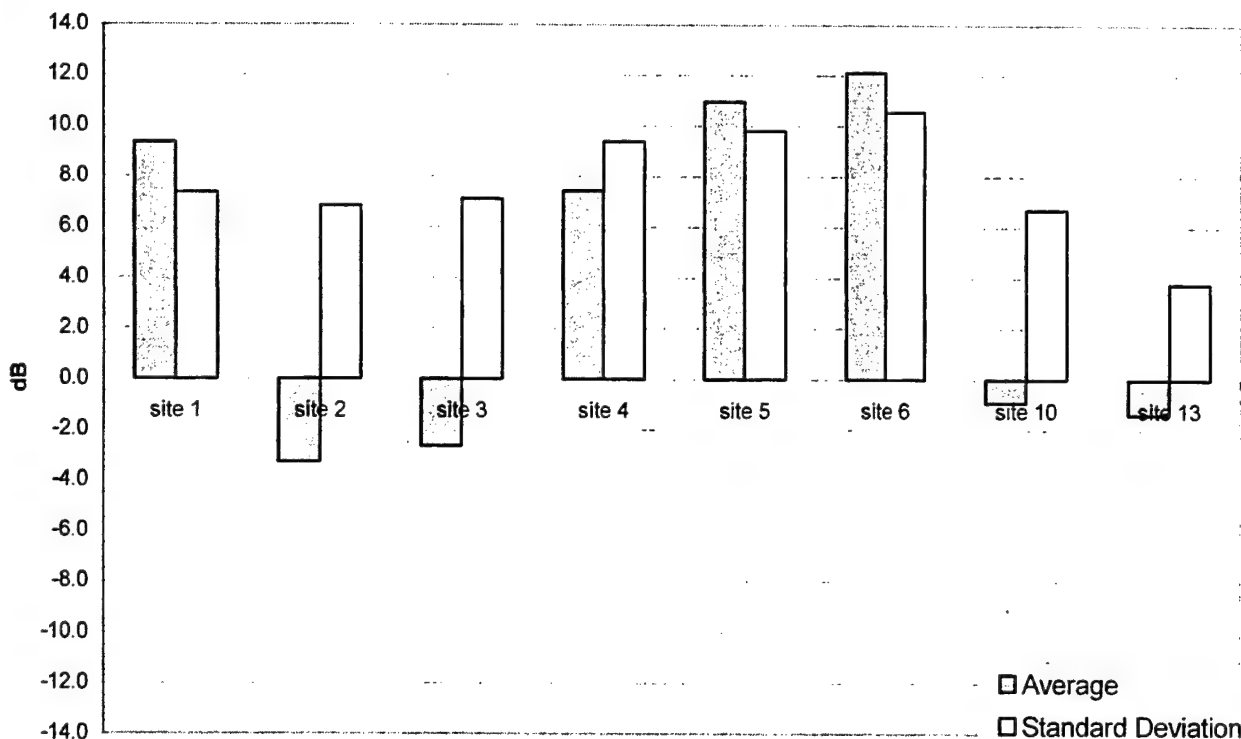


Figure 5. NAS Jacksonville Group 3: Miscellaneous Runway 27 Arrivals
Differences between Measured and Calculated SEL's

For the arrival profiles, Tables 3 and 4, along with Figures 4 and 5, display the differences between the measured and calculated SELs. The noise propagation is similar to that described above. However, for the comparison, the calculation method in NOISEMAP ends the flight profile at the runway threshold before touchdown of the aircraft. This modeling approach results in the landing roll not being modeled. Thus, for this comparison, the CPA used for the calculation for sites 1, 2, 3, 4 and 5 is the runway threshold at 50 ft. AGL. It should be noted that the standard deviations are larger for the miscellaneous group in Table 4. These resulted from uncertainty in the individual flight profiles for these various aircraft.

The differences measured at Site 1 are large, but they are explained through the omission of the landing roll in the NOISEMAP methodology. Site 1 was at the opposition end of the arrivals to Runway 27. Thus, the calculated values used a propagation distance of approximately 7,000 feet, whereas the aircraft final ground roll would bring the aircraft within 5,000 feet. This difference in propagation distance should result in a 3 dB increase in the calculated levels. Another source of error resulted from the differences in speed from approximately 130 knots as the plane approaches the runway threshold to a minimum ground speed of 30 knots as the plane slows to taxi from the runway. This difference in speed

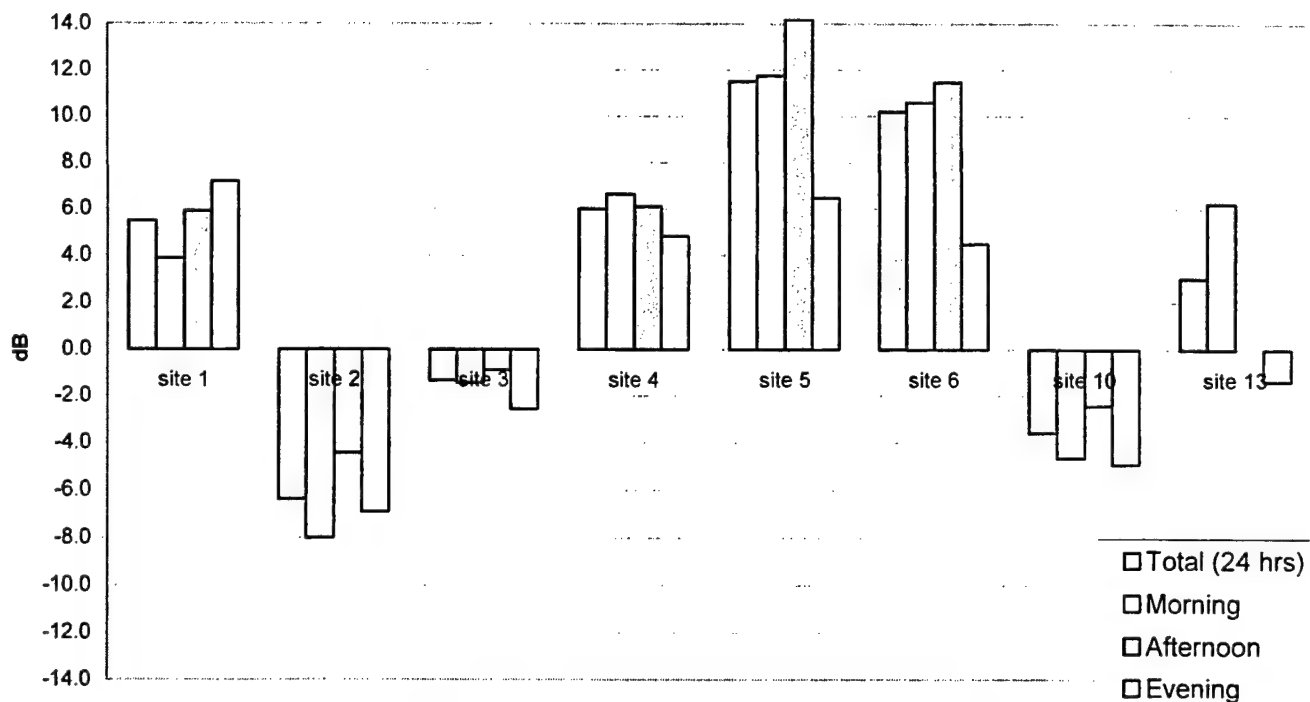
would tend to increase the measured SEL values since the site is being exposed to the noise for a longer duration. To account for this difference, the calculated level should be increased by approximately 6 dB. These corrections would result in the calculated values agreeing fairly well with the measured values.

At Site 2, the difference appeared to be relatively small, but, if the correction for landing roll were included, the difference would be about -5 to -8 dB, which again would suggest large ground absorption occurring near this site. At Sites 3 and 10, the differences were small, demonstrating good agreement between the measured and calculated levels. At Sites 4 and 5, a potential difference appeared, with differences of 5.4 and 7.4 dB occurring at Site 4 and 12.8 and 11.0 dB at Site 5. Similarly, significant differences of 11.7 and 12.1 dB occurred at Site 6. At Site 13, insufficient data were collected to make any type of statement.

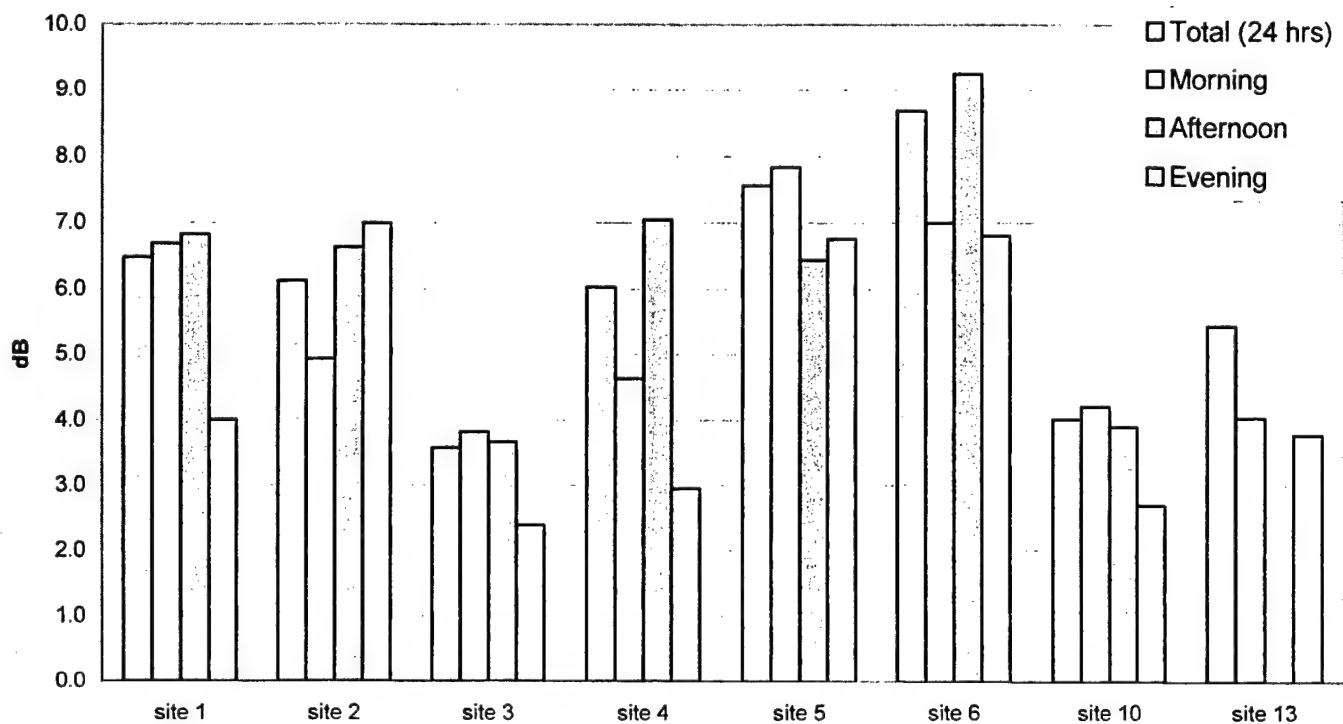
Another way to look at the differences is to group by time of day. This grouping aids in highlighting any influence of atmospheric conditions. The data are divided in the following manner: Morning (0600 - 1200 hours), Afternoon (1200 - 1800 hours), and Evening (1800 - 2400 hours). Table 5 and Figures 6 and 7 provide the statistics for this grouping. At Sites 5 and 6, the average differences were reduced during the evening hours. And, at most sites the variability was reduced during the evening hours.

Table 5. NAS Jacksonville Noise Data Grouped by Time of Day

	Total 24 hours			Morning (0600-1200)			Afternoon (1200-1800)			Evening (1800-2400)		
Site No.	Average difference (dB)	Standard deviation (dB)	Data count	Average difference (dB)	Standard deviation (dB)	Data count	Average difference (dB)	Standard deviation (dB)	Data count	Average difference (dB)	Standard deviation (dB)	Data count
1	5.5	6.5	69	3.9	6.7	21	5.9	6.8	38	7.2	4.0	10
2	-6.4	6.1	100	-8.0	4.9	46	-4.5	6.6	42	-6.9	7.0	12
3	-1.4	3.6	119	-1.5	3.8	43	-0.9	3.7	57	-2.6	2.4	19
4	6.0	6.0	53	6.6	4.6	11	6.1	7.1	33	4.8	3.0	9
5	11.5	7.6	103	11.8	7.8	31	14.2	6.4	46	6.5	6.8	26
6	10.2	8.7	72	10.6	7.0	17	11.5	9.3	44	4.5	6.8	11
10	-3.6	4.0	211	-4.6	4.2	75	-2.4	3.9	104	-4.9	2.7	32
13	3.0	5.4	19	6.2	4.0	11			0	-1.4	3.8	8



**Figure 6: NAS Jacksonville Time of Day Grouping
Average Differences between Measured and Calculated SEL's**



**Figure 7: NAS Jacksonville Time of Day Grouping
Stand Deviation of the differences between Measured and Calculated SEL's**

North Island

The data comparison was limited to individual SELs because of the lack of air traffic operational data counts. The data were separated into four groups: Departures from Runway 18, Arrivals to Runway 29, Departures from Runway 29, and Arrivals to Runway 36. This comparison was limited to events with duration less than 45 seconds to avoid cases where more than one aircraft contributed to the noise event. Figure 2 shows the layout of the monitoring sites. The monitors were set so that Sites 5, 7, 14 and 15 would measure aircraft noise levels that would be influenced by water surface. Sites 9, 10, 11 and 12 were on the airfield. Site 3 was on the ocean side of Point Loma and did not have a direct line of sight to the airfield. Site 4 was on the bay side of Point Loma and elevated above the airfield because of topography. Departures from Runway 18 and arrivals to Runway 36 should have produced noise events at the following sites: 7, 9, 10, 11, 12, 14 and 15. Arrivals to Runway 29 should have produced noise events at sites 10, 11, 12, 14 and 15. Departures from Runway 29 should have produced noise events at sites 4, 5, 7, 9, 10, 11 and, maybe, 3.

Table 6. North Island Group 1: Departure from Runway 18;
SEL Differences for Noise Events with Duration Less Than 45 Seconds;
Difference is Equal to the Measured SEL Minus the Calculated SEL

Site	SEL difference, dB	Standard deviation, dB	Data count	% Captured
7	3.7	4.2	110	52
9	0.5	5.4	113	53
10	4.6	4.6	98	46
11	-2.1	4.2	144	68
12	8.1	10.1	8	4
14	12.1	3.6	11	5
15	10.1	6.9	3	1

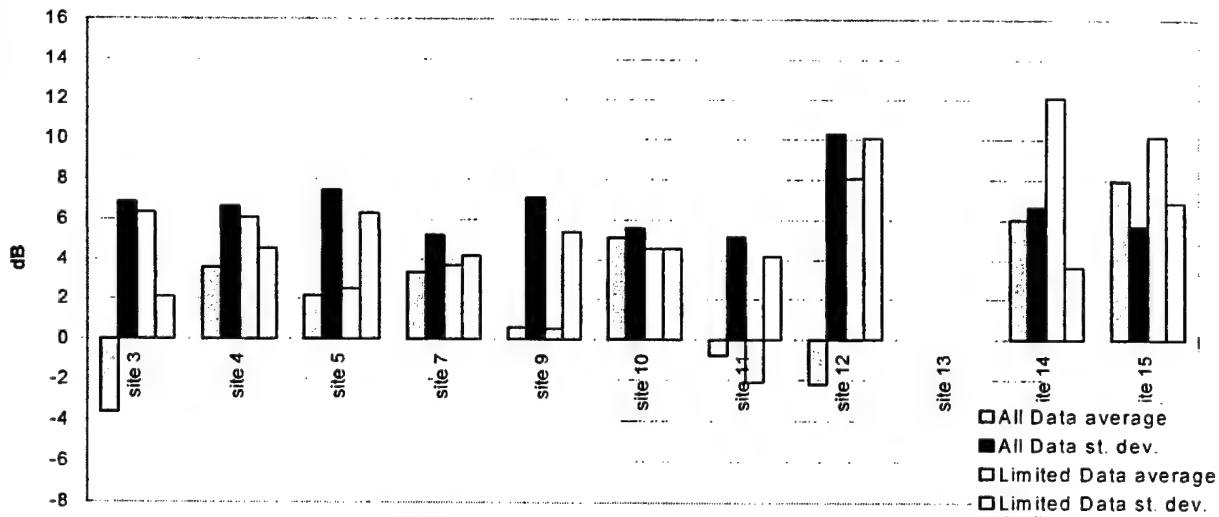


Figure 8: NAS North Island Overwater Noise Study
Difference between Measured and Predicted SELs: Runway 18 Departure

Table 6 and Figure 8 show the difference data for departures from Runway 18. The results at Sites 7 and 10 showed some difference, but the standard deviations were large. Insufficient data were obtained at Sites 12, 14 and 15 to generate any meaningful comparison. There was good agreement at Sites 9 and 11, where the noise propagated primarily over regular ground surface.

Table 7. North Island Group 2: Arrivals to Runway 29;
SEL Differences for Noise Events with Duration Less Than 45 Seconds;
Difference is Equal to the Measured SEL Minus the Calculated SEL

Site	SEL difference, dB	Standard deviation, dB	Data count	% Captured
10	5.8	3.8	110	57
11	8.3	5.2	20	10
12	2.0	4.7	183	95
14	0.05	4.9	169	88
15	3.1	5.9	20	10

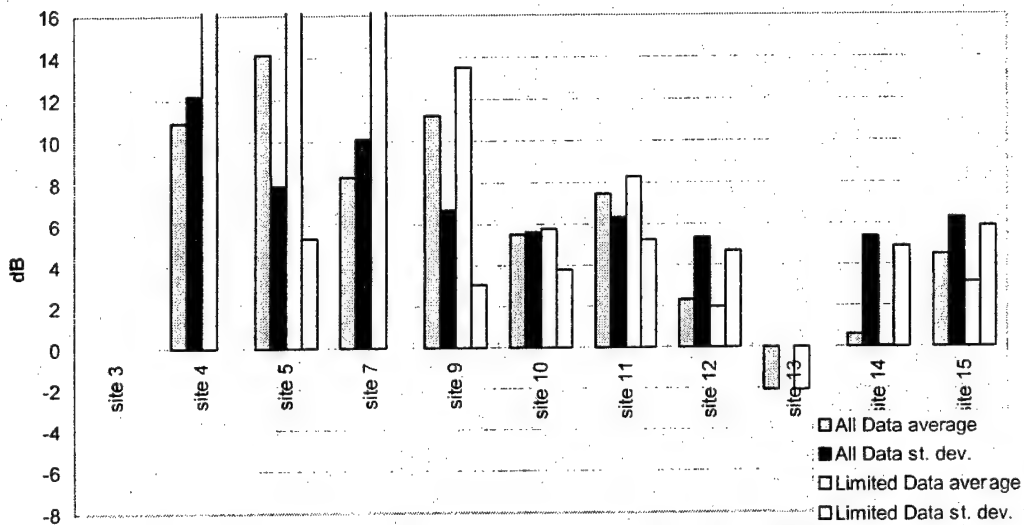


Figure 9: NAS North Island Overwater Noise Study
Difference between Measured and Predicted SELs: Runway 29 Arrival

Table 7 and Figure 9 show the results for arrivals to Runway 29. Only small differences were measured. The portion of the differences at Sites 10 and 11 resulted from the exclusion of the landing roll. The good agreement at Sites 12, 14 and 15 existed because the noise propagation slant angle was greater than 30°, resulting in little effect of the ground surface.

Table 8. North Island Group 3: Departures from Runway 29;
SEL Differences for Noise Events with Duration Less Than 45 Seconds;
Difference is Equal to the Measured SEL Minus the Calculated SEL

Site	SEL difference, dB	Standard deviation, dB	Data count	% Captured
3	-2.6	3.2	13	5
4	-0.7	4.5	62	23
5	-7.5	5.6	115	42
7	0.4	3.6	225	83
9	2.0	6.5	250	92
10	5.2	6.5	30	11
11	2.2	5.1	51	19

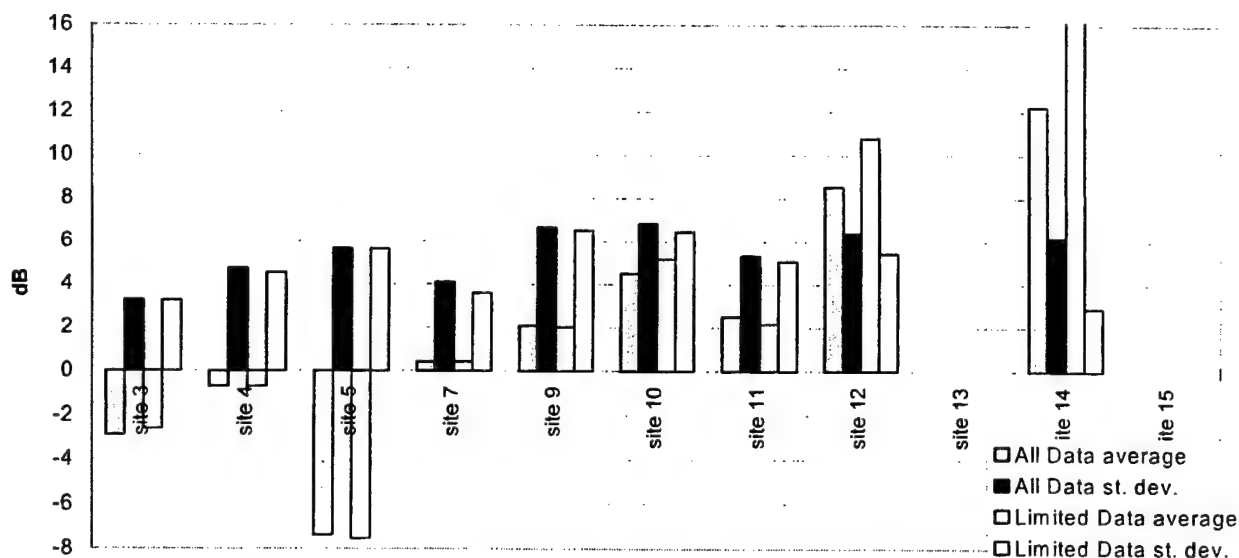


Figure 10: NAS North Island Overwater Noise Study
Difference between Measured and Predicted SELs: Runway 29 Departure

This group had the more confusing results that are given in Table 8 and Figure 10. An effect should have been observed at Site 5. However, a contrary difference of -7.5 dB was measured. This may have resulted from some type of insertion loss because of ships operating near this site. Good agreement exists at Sites 4 and 7 where the noise propagation was air-to-ground with no influence of the surface. This is true for Site 4 since it was elevated relative to the airfield. Sites 9, 10 and 11 show fair agreement as expected. A large difference was expected at Site 3 since it had no direct line of site to the airfield. However, the limited number of data points skewed the results at this site.

Table 9. North Island Group 4: Arrivals to Runway 36;
SEL Differences for Noise Events with Duration Less Than 45 Seconds;
Difference is Equal to the Measured SEL Minus the Calculated SEL

Site	SEL difference, dB	Standard deviation, dB	Data count	% Captured
7	14.2	5.5	6	32
9				0
10	11.2	2.3	5	26
11	-3.4	3.1	9	47
12				0
14				0
15				0

For Group 4, insufficient data were collected to draw any quantitative conclusions, as shown in Table 9. However, a large difference was observed at Sites 7 and 10. The difference at Site 7 probably resulted from over-water propagation. The difference at Site 10 resulted from the exclusion of landing roll that clearly underestimated the noise levels at this site.

The general observations from the North Island data set are that the variability in the data was large and limits any strong conclusion. The results from Site 7 suggest qualitatively that an effect occurred, since the change in the variability from Group 3 to Groups 1 and 4 was smaller than the change in the average SEL difference. This trend suggests that an enhancing effect was present. However, the data limitations do not allow any quantitative statement to be made about its magnitude. No effect was measured at Site 12, 14 and 15 since no data were collected where the water surface influenced the noise propagation to these sites.

This data set was also grouped according to time of day, and Table 10 and Figures 11 and 12 display the data. From this grouping, no strong influence was observed from atmospheric influences. This finding does suggest that the atmospheric conditions around North Island are fairly constant throughout the day.

Table 10. NAS North Island Noise Data Grouped by Time of Day

	Total 24 hours			Morning (0600-1200)			Afternoon (1200-1800)			Evening (1800-2400)		
Site No.	Average Difference (dB)	Standard deviation (dB)	Data count	Average difference (dB)	Standard deviation (dB)	Data count	Average difference (dB)	Standard deviation (dB)	Data count	Average difference (dB)	Standard deviation (dB)	Data count
3	-2.6	6.0	26	-2.0	5.3	8	-2.4	7.8	11	-3.4	3.5	7
4	1.1	6.1	104	0.5	6.0	40	2.1	6.5	47	-0.5	4.8	17
5	-4.0	8.4	168	-3.2	7.7	62	-4.4	9.3	87	-5.0	6.1	19
7	1.5	5.2	407	2.0	4.8	144	1.3	5.5	212	1.4	4.7	51
9	2.1	7.2	436	2.1	6.7	178	1.8	7.6	212	3.1	6.6	46
10	5.3	5.8	299	4.6	6.0	100	5.7	5.7	178	5.0	4.8	21
11	0.5	6.1	279	0.2	5.7	127	1.3	6.5	125	-1.7	5.3	27
12	2.1	6.2	270	0.6	6.9	80	2.8	5.9	169	1.8	5.6	21
14	1.3	5.9	246	0.3	6.3	68	1.8	5.8	161	1.1	4.4	17
15	5.0	6.2	31	6.8	6.8	8	5.74	6.72	16	1.5	2.8	7

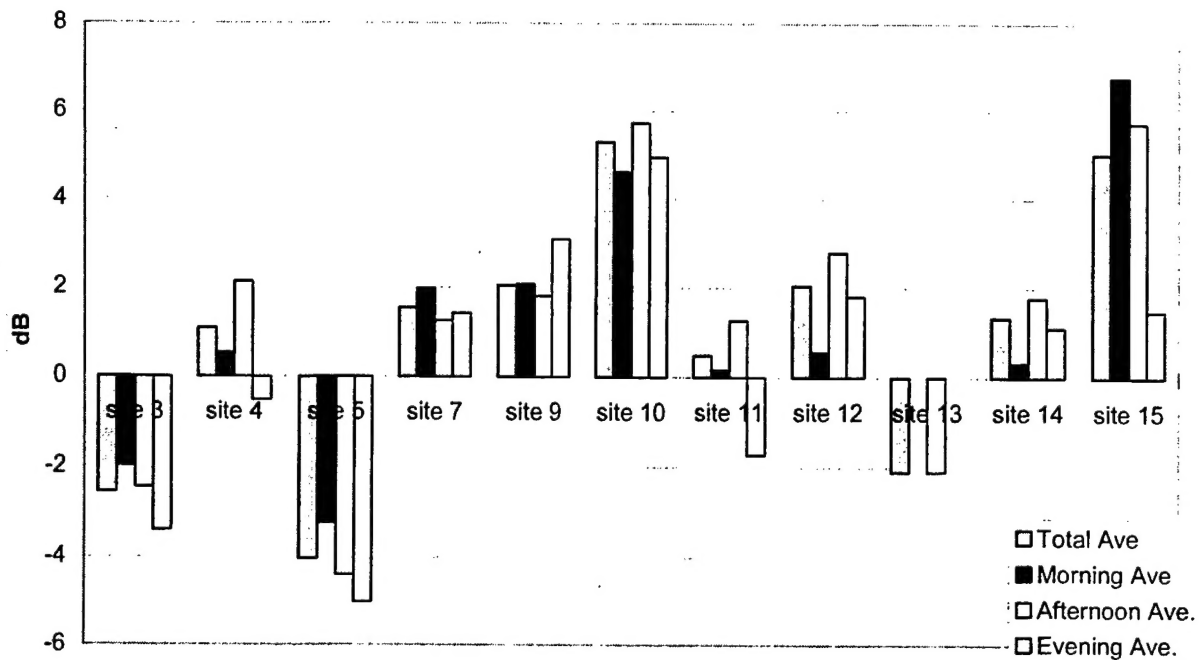


Figure 11: North Island NAS Noise Monitoring
Average Difference between Measured and Predicted SEL's Grouped by Time of Day

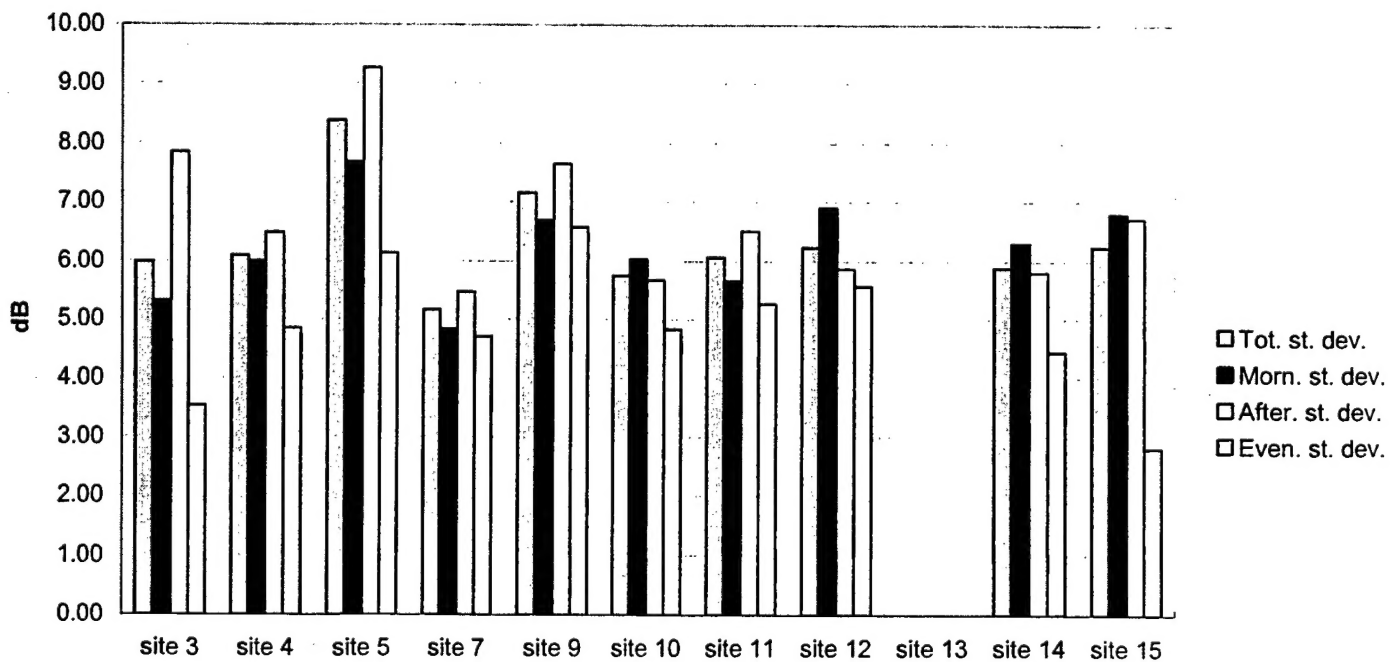


Figure 12: North Island NAS Noise Monitoring Data
St. Dev. of the Differences between Measured and Predicted SEL's Grouped by Time of Day

CONCLUSION

Aircraft noise was monitored around NAS Jacksonville and NAS North Island to assess the effect of noise propagation over water. The analysis approach involved comparing measured SEL values to calculated values using available radar tracking data and estimated power settings. From these preliminary noise studies, some effect of over-water propagation was observed. The comparison supports the use of modeling water surfaces as acoustically hard as a good first approximation. This modeling approach should be incorporated into NOISEMAP. The noise data did qualitatively display the trend that water surface can enhance noise exposure around an airfield by reducing the ground absorption, although the data were not precise enough to support any quantitative assessment about the exact magnitude of the effect. This limitation resulted mainly from the lack of precision in the aircraft tracking data. Other factors contributing to the data scatter were atmospheric effects, variations in engine power settings, and variations in aircraft performance. To determine a quantitative relationship between noise propagation and water surface, a more controlled measurement program will have to be undertaken. A specific study on the mechanisms of noise propagation over water should evaluate the important influencing parameters (i.e. temperature profile, wind profile, etc.) One important process that must be explored is how the water surface, via its influence on the atmospheric (temperature and wind) profile, may also indirectly affect noise propagation. This study should include both a stationary noise source and aircraft flyovers. The first phase should use a stationary source that would allow precise control of the source while bracketing the effects of atmospheric variations. The second phase should include aircraft flyovers to test and validate the algorithms in NOISEMAP 7.0. These more accurate tests can be used to determine the actual propagation path and determine the relative influence of ground surface and atmospheric conditions.

REFERENCES

1. "The NATO/CCMS Working Group Study: Effects of Topography on Propagation of Noise in the Vicinity of Airfields, Number 200," June 1, 1994.
2. Mohlman, H.T. "Updated Computer Programs for Predicting Single Event Aircraft Noise Data For Specific Engine Power and Meteorological Conditions," AL/OE-TR-1994-0008, April 1993.
3. Moulton, C.L. "Air Force Procedure for Predicting Noise Around Airbases: Noise Exposures Model (NOISEMAP) Technical Report," AL-TR-1992-0059, May 1992.
4. Schantz, B.D. and G.M. Sypek, "Aircraft Noise Study for Naval Air Station Jacksonville, Florida," Wyle Research Report, WR 96-4, June 1996.
5. Siwinski, B.J. and J.J. Czech, "Aircraft Noise Study for Naval Air Station North Island, CA," Wyle Research Report, WR 97-17, September 1997.